General

Guideline Title

ACR Appropriateness Criteria® seizures — child.

Bibliographic Source(s)

Dory CE, Coley BD, Karmazyn B, Charron M, Dempsey ME, Dillman JR, Garber M, Hayes LL, Holloway K, Milla SS, Raske ME, Rice HE, Rigsby CK, Rosenow JM, Strouse PJ, Westra SJ, Wootton-Gorges SL, Expert Panel on Pediatric Imaging. ACR Appropriateness CriteriaÂ® seizures -- child. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 9 p. [41 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Prince JS, Gunderman R, Coley BD, Bulas D, Holloway K, Karmazyn B, Meyer JS, Paidas C, Podberesky DJ, Ragheb J, Rodriguez W, Rosenow JM, Expert Panel on Pediatric Imaging. ACR Appropriateness Criteria® seizures - child. [online publication]. Reston (VA): American College of Radiology (ACR); 2009. 8 p.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Seizures – Child

Variant 1: Neonatal seizures.

Radiologic Procedure	Rating	Comments	RRL*
US head	9		O
MRI head without contrast	5	Particularly for hypoxic ischemic encephalopathy (HIE) and congenital malformations.	O
MRI head without and with contrast	4	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head without contrast	3		☢☢☢
CT head without and with contrast	3		☢☢☢☢
CT head with contrast	3		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative**

Radiologic Procedure	Rating	Comments	RRL*
FDG-PET/CT head	1		☢☢☢☢
SPECT head	1		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Simple febrile seizures.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	2		O
MRI head without and with contrast	2		O
CT head without contrast	2		☢☢☢
CT head without and with contrast	2		☢☢☢☢
CT head with contrast	2		☢☢☢
SPECT head	1		☢☢☢
FDG-PET/CT head	1		☢☢☢☢
US head	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Complex febrile seizures.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	4		O
MRI head without and with contrast	4		O
CT head without contrast	3		☢☢☢
CT head without and with contrast	3		☢☢☢☢
CT head with contrast	3		☢☢☢
SPECT head	2		☢☢☢
FDG-PET/CT head	1		☢☢☢☢
US head	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Post-traumatic seizures.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		☢☢☢
MRI head without contrast	[illegible]	Useful for detecting blood products and gliosis not seen on CT and in the chronic post-traumatic setting.	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	3		O
CT head without and with contrast	2		☢☢☢☢
CT head with contrast	2		☢☢☢
US head	1		O
FDG-PET/CT head	1		☢☢☢☢
SPECT head	1		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Partial seizures.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	9		O
MRI head without and with contrast	7	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head without and with contrast	5	If MRI unavailable or contraindicated.	☢☢☢☢
CT head with contrast	5	If MRI unavailable or contraindicated.	☢☢☢
FDG-PET/CT head	5	Recurrent seizure.	☢☢☢☢
SPECT head	5	Recurrent seizure.	☢☢☢
CT head without contrast	3	If MRI unavailable or contraindicated.	☢☢☢
US head	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: First generalized seizure (neurologically normal).

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	5		O
MRI head without and with contrast	4	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head without contrast	4		☢☢☢
CT head without and with contrast	2		☢☢☢☢
CT head with contrast	2		☢☢☢
SPECT head	1		☢☢☢
FDG-PET/CT head	1		☢☢☢☢
US head	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Generalized seizures (neurologically abnormal).

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	9		O
CT head without contrast	6		☢☢☢
MRI head without and with contrast	6	To clarify an abnormality on the noncontrast MRI or if considering infection or inflammation. See statement regarding contrast in text under "Anticipated Exceptions."	O
FDG-PET/CT head	2		☢☢☢☢
CT head without and with contrast	2		☢☢☢☢
CT head with contrast	2		☢☢☢
SPECT head	2		☢☢☢
US head	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 8: Intractable or refractory seizures.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	9		O
MRI head without and with contrast	6	To clarify an abnormality on the noncontrast MRI or if considering infection or inflammation. See statement regarding contrast in text under "Anticipated Exceptions."	O
FDG-PET/CT head	6		☢☢☢☢
SPECT head	6		☢☢☢
CT head without contrast	5		☢☢☢
CT head without and with contrast	2		☢☢☢☢
CT head with contrast	2		☢☢☢
US head	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

Seizures present common management problems in medical practice, particularly in pediatrics. In the United States, about 120,000 individuals under the age of 18 have a first seizure each year. Ten percent of the American population will experience a seizure during their lifetime, and 45,000 cases of epilepsy are diagnosed in children under the age of 15 each year. Epileptic seizures in children under the age of 10 are likely to be generalized, while epileptic seizures are more commonly partial in children older than age 10.

Seizures are defined as "a transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain." There are a number of classification schemes of seizures. One frequently referenced is the International League Against Epilepsy (ILAE), as

modified recently by the ILAE Classification Core Group. However, none of the current classifications neatly fit into categories that can be used to propose imaging guidelines. To alleviate this problem, patients have been categorized into groups for which specific imaging modes seem appropriate. The groupings, which are described below, are based on patient age, precipitating event, and clinical manifestations of the seizure, coupled with electroencephalogram (EEG) findings.

Imaging Recommendations

The clinical manifestations of a seizure, in conjunction with an EEG, classify it as either generalized or partial. This is the most important distinction related to imaging. The historical data are sometimes limited, and accurate determination of specific seizure category may be difficult. The initial imaging of a patient presenting with a seizure may require supplemental imaging as the nature of the seizure becomes more defined or if the seizures become more frequent or refractory to treatment.

Neonatal Seizure

The incidence of neonatal seizures has been estimated to be 3 per 1,000 live births per year. The rate is higher in preterm infants (57 to 132 per 1,000 live births). Hypoxic ischemic encephalopathy is by far the most common cause of seizure in both term and preterm infants. Intracranial hemorrhage is the second leading cause. Together they account for nearly 75% of seizures in the neonatal period. Approximately 90% of infants with hypoxic ischemic encephalopathy experience the onset of their seizures within two days following birth. Seizures occurring beyond the seventh day of life are more likely to be related to infection or developmental defects.

Ultrasound (US) is the mainstay for imaging the neonatal brain. Its portability and ease of evaluation at the bedside make it an ideal method of evaluation. US does not involve radiation exposure in these susceptible patients. Magnetic resonance imaging (MRI) is increasingly valuable, particularly in defining the extent of parenchymal injury. Diffusion imaging has added sensitivity to routine spin-echo sequences. In addition, MRI has the greatest sensitivity for detecting intracranial developmental abnormalities associated with seizures, specifically malformations of cortical development. MRI-compatible incubators and the sophistication of neonatal care teams in managing critical neonates in the MRI environment have allowed for increased MRI use.

Computed tomography (CT) can play a role in defining the extent of hemorrhage and is useful in quantifying and characterizing extra-axial collections, but it involves ionizing radiation and is less sensitive than MRI for evaluating hypoxic ischemic events and structural anomalies.

Febrile Seizure

Between 2% and 5% of children have febrile seizures. About one-third of them will have at least one recurrence. Febrile seizures occur between 3 months and 5 years of age and are associated with fever, but without evidence of intracranial infection or other defined cause. Simple febrile seizures last <15 minutes and do not recur within 24 hours. There is no indication for imaging simple febrile seizures. Complex febrile seizures (which are prolonged, recur more than once in 24 hours, or are focal) are rarely associated with underlying pathology such as meningitis, encephalitis, or child abuse. Brain abnormalities may lower seizure threshold in febrile children. Imaging, preferably with MRI or CT, may be performed in selected patients with complex febrile seizures when meningitis/encephalitis or underlying trauma is suspected.

It remains controversial whether febrile seizures, particularly prolonged complex febrile seizures, cause the later development of mesial temporal sclerosis (MTS). There is growing evidence that hippocampal swelling and restricted diffusion, which can be identified on coronal MRI, maybe associated with MTS later in life. Such findings, however, are of little clinical significance at the time of the febrile event and do not assist in immediate patient management.

Post-traumatic Seizure

Seizures may occur secondary to intracranial trauma. CT and MRI both effectively define treatable pathology associated with intracranial trauma. In one study, CT identified 100% of the treatable lesions in patients with mild trauma as indicated by Glasgow Coma Scores of 13 to 15. In this study, although CT results were negative in 53% of patients, 7% of patients had lesions that required surgical intervention. MRI is generally less appropriate in the acute trauma setting, depending on the overall clinical status of the child. However, it can be useful in detecting intracranial blood as well as post-traumatic gliosis. An important subgroup to consider for CT is the patient younger than age 2 presenting to the emergency department with a first-time afebrile seizure, as this may be a presentation of nonaccidental trauma (child abuse).

Partial Seizure

The occurrence of a partial seizure implies an origin of the seizure in a focal (but not necessarily small) area of the brain, with a tendency for propagation. Focality is also suggested through EEG analysis. Positive yields from imaging of patients with partial seizures, both simple (without loss of consciousness) and complex (with loss of consciousness), are considerably higher than those from imaging of patients with generalized seizures whose neurologic examination is normal. In one study, neuroimaging was positive in more than 50% of patients whose seizures had focal

features. MRI was considerably more sensitive than CT. Another study noted a 50% positivity rate for CT when neurologic findings were focal. A third study found seizures to be the presenting symptom in 12% of 81 consecutive children with primary brain tumors. Nine of 10 seizures in this series were focal.

Seizures can result from developmental abnormalities, hemorrhage, neoplasm, and gliosis, all of which can be detected by CT and MRI. MRI is considerably more sensitive than CT, particularly with subtle developmental abnormalities, small foci of hemorrhage, and metastases. The argument that CT is more accessible for emergent imaging of initial seizure is offset by the improved sensitivity of MRI. One study suggests limited justification for emergent CT as opposed to scheduled MRI in patients presenting with first-time seizure. One exception might be the patient younger than age 2 years in whom the possibility of nonaccidental trauma (child abuse) should be considered. The rate of recurrence of partial seizures was considerably greater than that for generalized seizures. In one study, patients with partial seizures had a 94% rate of recurrence.

Both fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) and single-photon emission computed tomography (SPECT) (ictal and interictal) can be helpful in evaluating recurrent seizures when anatomic imaging (CT and MRI) is normal. In general, however, functional imaging (FDG-PET, SPECT, functional MRI, and even magnetoencephalography) is most appropriately reserved for refined evaluation when surgical intervention is contemplated.

Generalized Seizure (less than 2 unprovoked seizures)

Patients with generalized seizures are divided into two subcategories: those who are neurologically normal and those who present with positive neurologic findings. Neurologic abnormalities may be historical, such as developmental delay, cerebral palsy, or attention deficit disorder. They may also be physical, as in postictal Todd's paralysis, or simply manifest as an abnormal sensorium. Fewer than 2% of patients will have an abnormal CT examination after a generalized seizure if they are neurologically normal with a negative EEG. In one study, none of the positive CT findings were treatable. In another study, 100% of patients with abnormal studies had either a positive neurologic examination, a positive EEG, or a known malignancy. A third study reported only 6% positive CT examinations for generalized seizures, with nearly 50% positivity in focal epilepsy. Another group of researchers studied 500 consecutive patients presenting to an emergency department with first afebrile seizure. They defined two clinically significant high-risk indicators of positive examination: 1) presence of predisposing condition and 2) focal seizure. Only 2% of low-risk patients had positive imaging examinations.

Patients with generalized seizures with abnormal neurologic findings should be evaluated with MRI. A difficult task in the evaluation of seizures is discriminating a generalized seizure whose onset is precipitated by a focal epileptic event from one without a focal precipitant. Many of these patients, however, demonstrate either a postictal neurologic finding or other neurologic abnormality including nonspecific findings such as developmental delay. Although one study reported that 83% of patients younger than 16 years of age at the time of initial seizure experienced a second seizure, 100% of seizures associated with a neurologic deficit recurred.

Seizure Syndromes

A number of seizure syndromes probably do not require imaging because they are sufficiently characteristic to be diagnosed clinically or through specific EEG patterns. Benign rolandic seizures, benign occipital epilepsy, and juvenile myoclonic seizures are fairly characteristic and rarely benefit from imaging. Patients with the malignant form of rolandic seizure without typical EEG findings may benefit from imaging. MRI is most likely positive when the EEG shows focal abnormality. West syndrome has been divided into symptomatic and asymptomatic forms. There are conflicting data as to the utility of SPECT and FDG-PET in the evaluation of West syndrome (also known as infantile spasms). MRI is probably indicated in symptomatic forms because there is a significant incidence of cortical dysplasia that can benefit from surgical management. Children presenting with absence seizures along with classic EEGs do not need to be imaged.

Intractable or Refractory Seizures

Refractory seizures, which are potentially treatable by surgical intervention, define a small percentage of patients with seizures or epilepsy. In these patients, the use of both anatomical and functional imaging modalities is needed in selected cases. MRI is considered the most sensitive and specific anatomic imaging technique in the evaluation of these patients. It is more sensitive (84%) than SPECT (75%), which is somewhat more sensitive than CT (62%) in surgical patients with intractable seizures. MRI is particularly useful in the evaluation of MTS, periventricular white matter abnormalities, and cortical abnormalities which may be the cause of refractory seizures.

Ictal SPECT has been useful in differentiating temporal lobe epilepsy from extratemporal lobe foci and provides noninvasive imaging information used in planning treatment strategies. Ictal SPECT optimization requires radiopharmaceutical injection (technetium [Tc]-99m hexamethylpropyleneamine oxime [HMPAO] or Tc-99m ethyl cysteinate dimer [ECD]) within seconds of a seizure. This practical limitation has made ictal imaging difficult, except in specialized inpatient centers. There is general agreement that the combination of ictal and interictal SPECT is the optimal method of SPECT imaging in the evaluation of seizure focus. Pharmacologic provocation of a seizure focus has been studied as a way to more reliably obtain a true ictal examination. FDG-PET is an alternative to SPECT for functional imaging and is most useful in patients with

intractable partial epilepsy. Evidence that FDG-PET has prognostic value regarding the outcome of epilepsy surgery in refractory partial epilepsy is beginning to accumulate. In particular, FDG-PET has been shown to be useful in evaluating residual foci of seizure activity in patients who have undergone unsuccessful surgical intervention. SPECT is currently more available than PET, although the emergence of PET/CT has resulted in increased availability. Both SPECT and FDG-PET have been used in some centers as a part of presurgical evaluation and planning.

Summary

- The appropriate imaging of pediatric patients being evaluated for seizures is variable and depends on the age at presentation, the seizure characteristics, the precipitating event, and the associated neurologic findings.
- US should be the first imaging modality for evaluating neonatal seizures. MRI should be considered in these children because it can detect a high percentage of abnormalities.
- MRI is more sensitive than CT in defining structural abnormalities associated with a seizure focus.
- Imaging, preferentially MRI, is indicated in partial seizures and generalized seizures accompanied by abnormal neurologic findings or other risk factors.
- Simple febrile seizures do not require imaging evaluation.
- In selected cases, when infection or trauma is suspected, complex febrile seizures can be evaluated with MRI or CT.
- Post-traumatic seizures should first be evaluated by CT. Late post-traumatic seizures may be better evaluated by MRI.
- Refractory or intractable seizures are best imaged with MRI followed by a functional study such as SPECT or PET.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the American College of Radiology (ACR) Manual on Contrast Media (see the "Availability of Companion Documents" field).

Abbreviations

- CT, computed tomography
- FDG-PET, fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography
- MRI, magnetic resonance imaging
- SPECT, single-photon emission computed tomography
- US, ultrasound

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Seizures:

- Neonatal
- Simple febrile
- Complex febrile
- Post-traumatic
- Partial
- First generalized (neurologically normal)
- Generalized (neurologically abnormal)
- Intractable or refractory

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Critical Care

Emergency Medicine

Family Practice

Infectious Diseases

Neurology

Nuclear Medicine

Pediatrics

Radiology

Intended Users

Health Plans

Hospitals

Managed Care Organizations

Physicians

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of initial radiologic examinations for pediatric patients with seizures

Target Population

Children with seizures

Interventions and Practices Considered

1. Magnetic resonance imaging (MRI) head
    - Without contrast
    - Without and with contrast
2. Computed tomography (CT) head
    - Without contrast
    - Without and with contrast
    - With contrast
3. Ultrasound (US) head
4. Fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET)/CT head
5. Single-photon emission computed tomography (SPECT) head

Major Outcomes Considered

Utility of radiologic examinations in differential diagnosis

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Procedure

The Medline literature search is based on keywords provided by the topic author. The two general classes of keywords are those related to the condition (e.g., ankle pain, fever) and those that describe the diagnostic or therapeutic intervention of interest (e.g., mammography, MRI).

The search terms and parameters are manipulated to produce the most relevant, current evidence to address the American College of Radiology Appropriateness Criteria (ACR AC) topic being reviewed or developed. Combining the clinical conditions and diagnostic modalities or therapeutic procedures narrows the search to be relevant to the topic. Exploding the term "diagnostic imaging" captures relevant results for diagnostic topics.

The following criteria/limits are used in the searches:

1. Articles that have abstracts available and are concerned with humans.
2. Restrict the search to the year prior to the last topic update or in some cases the author of the topic may specify which year range to use in the search. For new topics, the year range is restricted to the last 5 years unless the topic author provides other instructions.
3. May restrict the search to Adults only or Pediatrics only.
4. Articles consisting of only summaries or case reports are often excluded from final results.

The search strategy may be revised to improve the output as needed.

Number of Source Documents

The total number of source documents identified as the result of the literature search is not known.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Strength of Evidence Key

Category 1 - The conclusions of the study are valid and strongly supported by study design, analysis, and results.

Category 2 - The conclusions of the study are likely valid, but study design does not permit certainty.

Category 3 - The conclusions of the study may be valid, but the evidence supporting the conclusions is inconclusive or equivocal.

Category 4 - The conclusions of the study may not be valid because the evidence may not be reliable given the study design or analysis.

Methods Used to Analyze the Evidence

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author drafts or revises the narrative text summarizing the evidence found in the literature. American College of Radiology (ACR) staff draft an evidence table based on the analysis of the selected literature. These tables rate the strength of the evidence for all articles included in the narrative text.

The expert panel reviews the narrative text, evidence table, and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the table. Each individual panel member forms his/her own opinion based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Modified Delphi Technique

The appropriateness ratings for each of the procedures included in the Appropriateness Criteria topics are determined using a modified Delphi methodology. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. American College of Radiology (ACR) staff distributes surveys to the panelists along with the evidence table and narrative. Each panelist interprets the available evidence and rates each procedure. The surveys are completed by panelists without consulting other panelists. The ratings are a scale between 1 and 9, which is further divided into three categories: 1, 2, or 3 is defined as "usually not appropriate"; 4, 5, or 6 is defined as "may be appropriate"; and 7, 8, or 9 is defined as "usually appropriate." Each panel member assigns one rating for each procedure per survey round. The surveys are collected and the results are tabulated, de-identified and redistributed after each round. A maximum of three rounds are conducted. The modified Delphi technique enables each panelist to express individual interpretations of the evidence and his or her expert opinion without excessive bias from fellow panelists in a simple, standardized and economical process.

Consensus among the panel members must be achieved to determine the final rating for each procedure. Consensus is defined as eighty percent (80%) agreement within a rating category. The final rating is determined by the median of all the ratings once consensus has been reached. Up to three rating rounds are conducted to achieve consensus.

If consensus is not reached, the panel is convened by conference call. The strengths and weaknesses of each imaging procedure that has not reached consensus are discussed and a final rating is proposed. If the panelists on the call agree, the rating is accepted as the panel's consensus. The document is circulated to all the panelists to make the final determination. If consensus cannot be reached on the call or when the document is circulated, "No consensus" appears in the rating column and the reasons for this decision are added to the comment sections.

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current literature and expert panel consensus.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Selection of appropriate radiologic imaging procedures for evaluation of pediatric patients with seizures

Potential Harms

Computed tomography (CT) involves ionizing radiation and is less sensitive than magnetic resonance imaging (MRI) for evaluating hypoxic ischemic events and structural anomalies.

Gadolinium-based Contrast Agents

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the

type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the American College of Radiology (ACR) Manual on Contrast Media (see the "Availability of Companion Documents" field).

Relative Radiation Level (RRL)

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Living with Illness

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Dory CE, Coley BD, Karmazyn B, Charron M, Dempsey ME, Dillman JR, Garber M, Hayes LL, Holloway K, Milla SS, Raske ME, Rice HE, Rigsby CK, Rosenow JM, Strouse PJ, Westra SJ, Wootton-Gorges SL, Expert Panel on Pediatric Imaging. ACR Appropriateness CriteriaÂ® seizures -- child. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 9 p. [41 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

1995 (revised 2012)

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Pediatric Imaging

Composition of Group That Authored the Guideline

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Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Prince JS, Gunderman R, Coley BD, Bulas D, Holloway K, Karmazyn B, Meyer JS, Paidas C, Podberesky DJ, Ragheb J, Rodriguez W, Rosenow JM, Expert Panel on Pediatric Imaging. ACR Appropriateness Criteria® seizures - child. [online publication]. Reston (VA): American College of Radiology (ACR); 2009. 8 p.

Guideline Availability

Electronic copies: Available from the American College of Radiology (ACR) Web site .

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site .
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Evidence table development – diagnostic studies. Reston (VA): American College of Radiology; 2013 Nov. 3 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 90 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria® seizures — child. Evidence table. Reston (VA): American College of Radiology; 2012. 12 p. Electronic copies: Available in PDF from the ACR Web site .

Patient Resources

None available

NGC Status

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